Impacts of the Atlantic Multidecadal Variability on North American Summer Climate and Heat Waves

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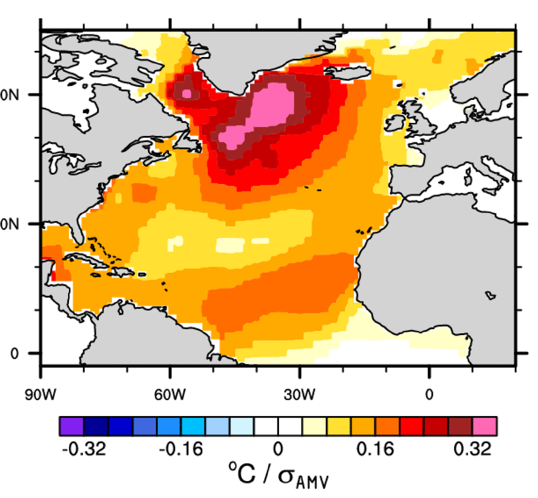
INADEC
H2020-MSCA-800154

Introduction: The impacts of the Atlantic Multidecadal Variability (AMV) on the summer North American climate are investigated using three Coupled Global Climate Models (CGCMs) in which the North Atlantic sea surface temperatures (SSTs) are restored to observed AMV anomalies. In response to an **AMV warming**, all models simulate a **precipitation deficit** and a **warming** over **Northern Mexico and Southern US** that lead to an **increased number of heat wave days by about 30%** compared to an AMV cooling.

Models: We use three coupled climate models: **CM2.1**, **CESM1** and **FLOR**. All the models share similar oceanic resolution (~1°), but different atmospheric resolution: 200km, 100km, and 50km, respectively.

1) Experimental protocol

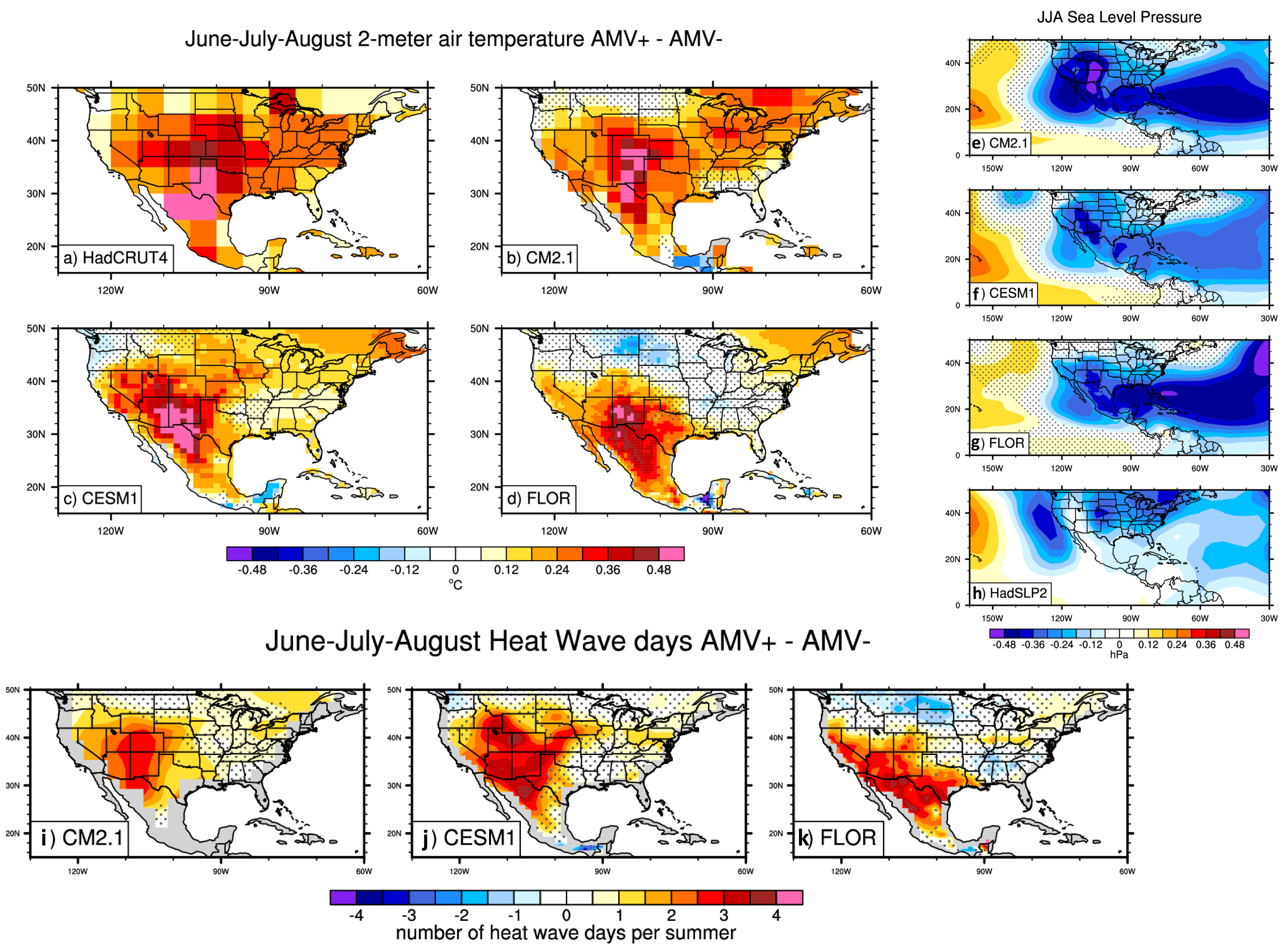


- North Atlantic SSTs restored to the fixed **observed AMV** pattern with a 5/15-day restoring time scale
- 10yr long ensemble experiments: CM2.1 - 100 members, CESM1 - 30mb, FLOR - 50mb
- Free ocean-atmosphere interactions outside the North Atlantic → allows Pacific adjustment

3 experiments:

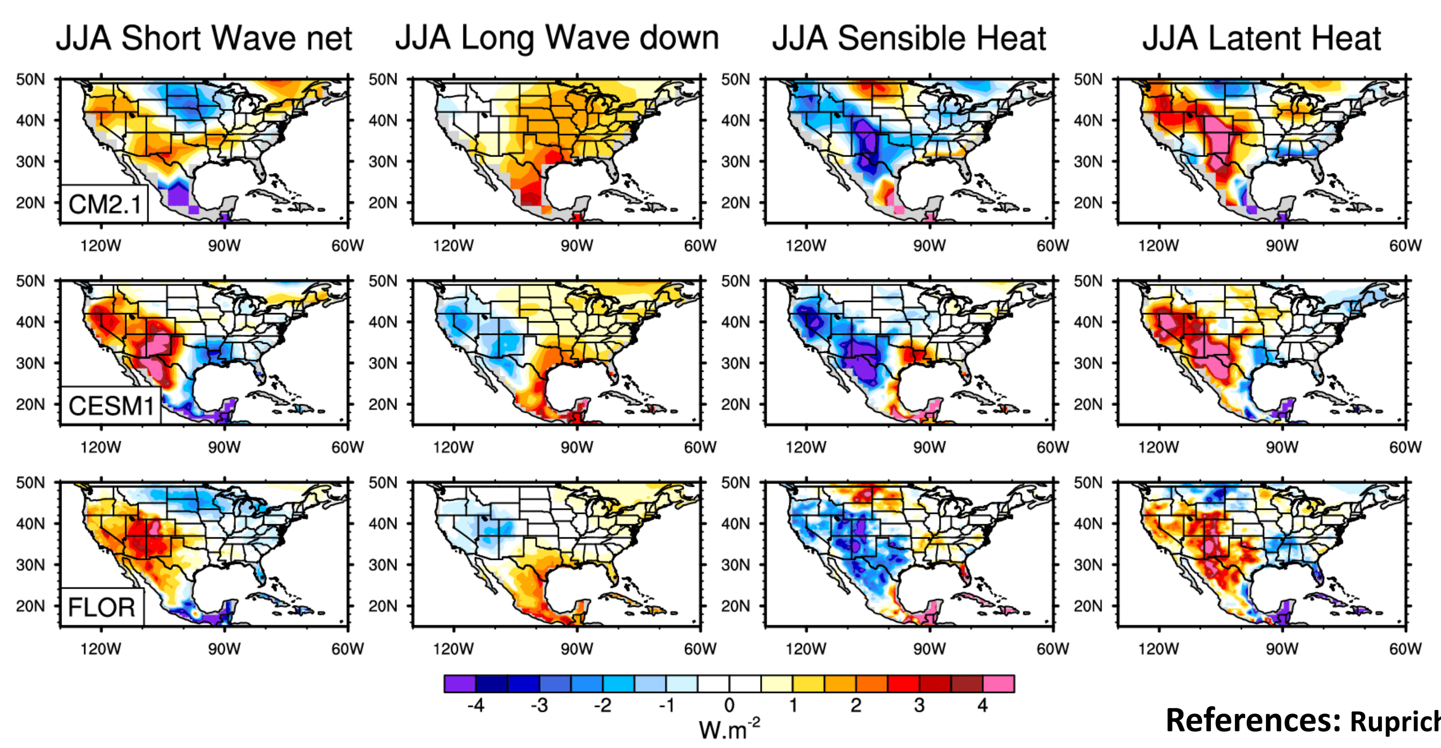
- **Full_AMV**: North Atlantic SST restored from **5ºN to 65ºN** to positive/negative phase of AMV
- **Trop_AMV**: North Atlantic SST restored from **5ºN to 25ºN** to positive/negative phase of AMV
- **DampGlo_AMV**: same as Full_AMV + global SST restored to climatology

2) Summertime surface condition responses



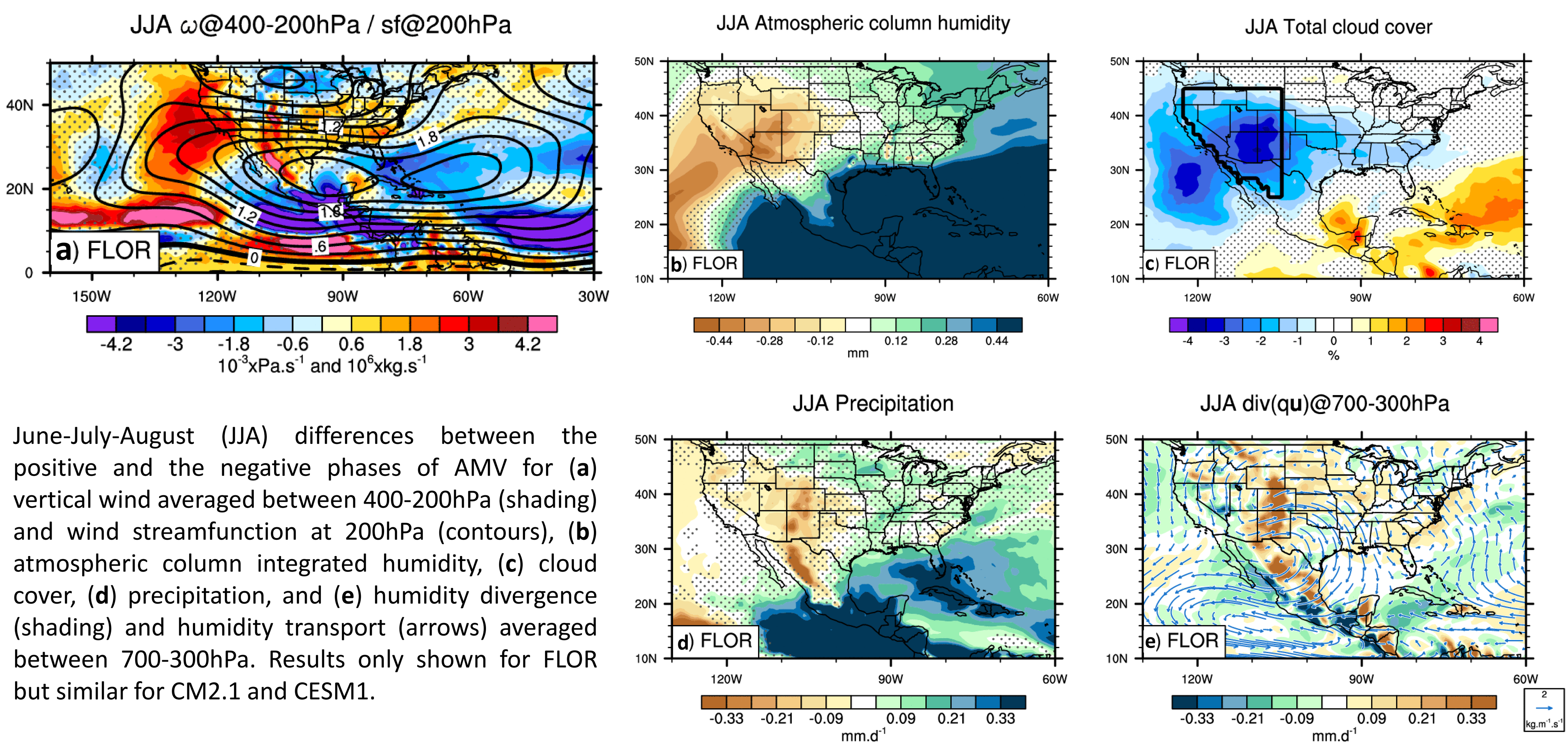
Differences between the positive and the negative phases of AMV. (**a**,**b**,**c**,**d**) June-July-August (JJA) 2-meter air temperature from Observation, CM2.1, CESM1, and FLOR. (**e**,**f**,**g**,**h**) same as (a,b,c,d) but for sea level pressure. (**i**,**j**,**k**) Number of heat wave days. Heat waves are computing taking into account both intensity and length criteria (following Lau and Nath 2012). The number of heat wave days is the number of day per JJA season belonging to a heat wave event. Stippling indicates regions that are below the 95% confidence level of statistical significance according to a two-sided t-test.

3) Surface heat flux responses



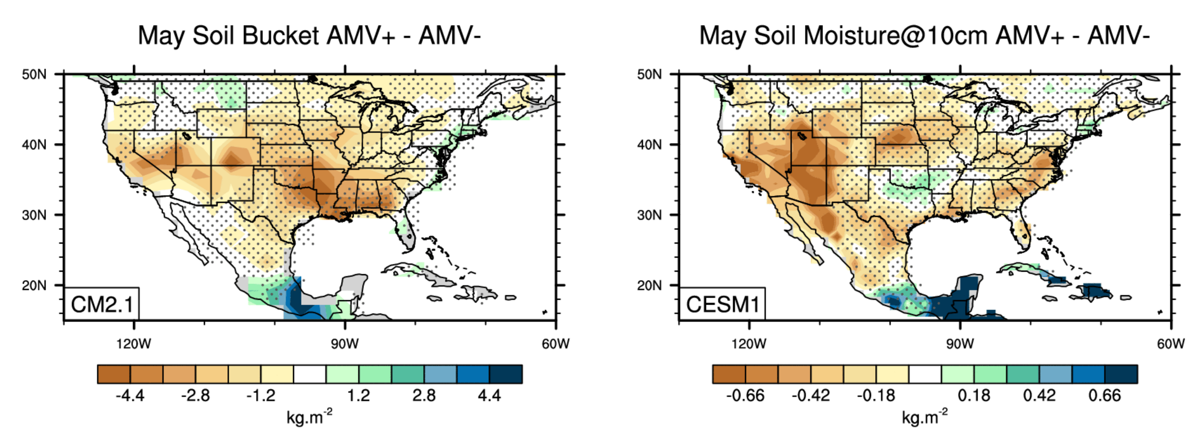
Differences in 10-year June-July-August average surface flux differences between AMV+ and AMV- experiments. The fluxes are shown for grid cells containing only land surface area. Positive anomalies indicate a surface warming.

4) Summertime atmospheric changes

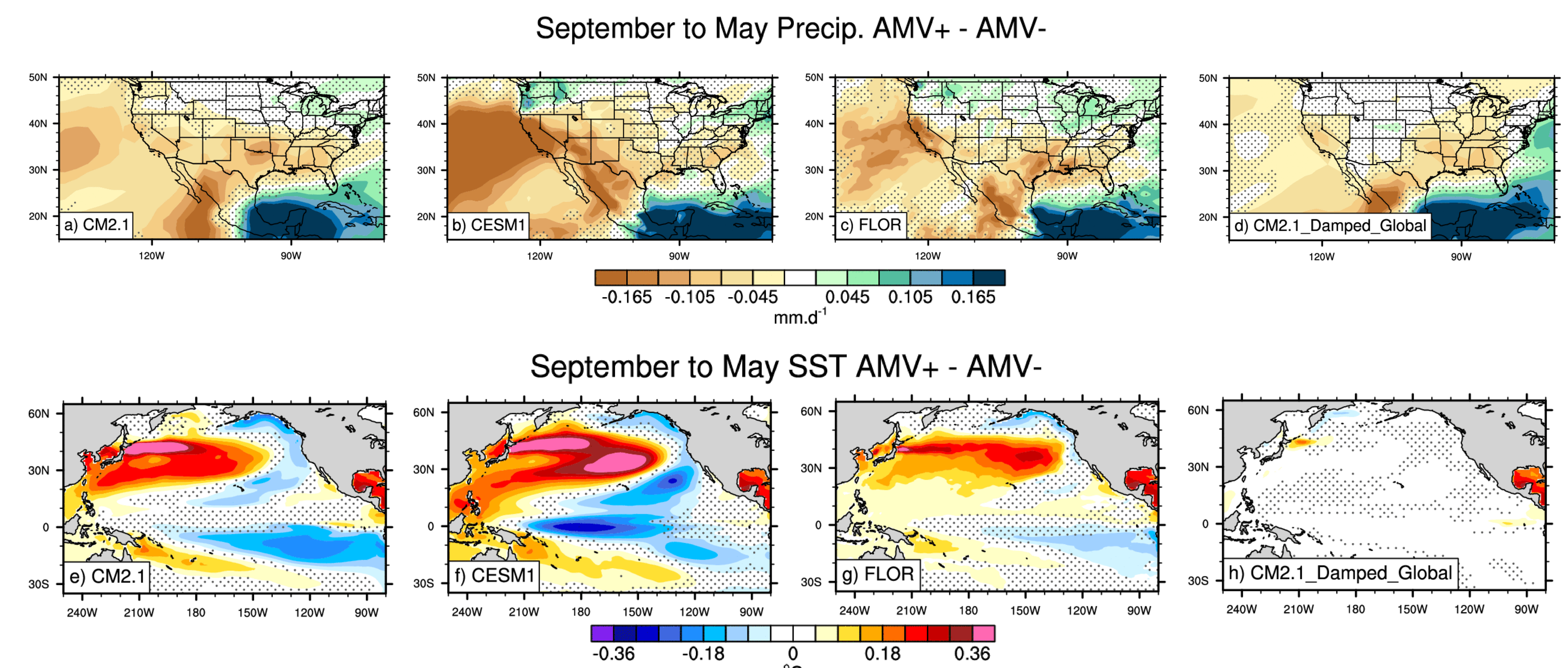


June-July-August (JJA) differences between the positive and the negative phases of AMV for (**a**) vertical wind averaged between 400-200hPa (shading) and wind streamfunction at 200hPa (contours), (**b**) atmospheric column integrated humidity, (**c**) cloud cover, (**d**) precipitation, and (**e**) humidity divergence (shading) and humidity transport (arrows) averaged between 700-300hPa. Results only shown for FLOR but similar for CM2.1 and CESM1.

5) Soil moisture pre-conditioning



(**left**) May soil moisture differences between the positive and the negative phases of AMV. (**bottom**) September to May precipitation (**a**,**b**,**c**,**d**) and sea surface temperature (**e**,**f**,**g**,**h**) differences between the positive and the negative phases of AMV.



Conclusions:

- AMV tropical SST warming favors subsidence over North-West Mexico and West US
- Subsidence warms upper troposphere + decrease relative humidity → more solar radiation
- Summer solar radiation + summer precipitation deficit warm the surface (SW_{net} + latent heat) → thermal-low response over Northern Mexico and Southwestern US
- Soil moisture deficit due to precipitation anomalies occurring all year-long (cf. Pacific SSTs response) also acts as a preconditioning for the development of heat waves.

References: **Ruprich-Robert, Y., T. Delworth, R. Msadek, F. Castruccio, S. Yeager, and G. Danabasoglu** (2018) Impacts of the Atlantic Multidecadal Variability on North American Summer Climate and Heat Waves. J. Clim. doi: 10.1175/JCLI-D-17-0270.1